INFLUENCE OF PEAK GROUND ACCELERATION AND SOIL TYPE ON SEISMIC DESIGN OF RC HOTEL BULDING

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is based on my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously or concurrently submitted for any other degree at Universiti Malaysia Pahang or any other institutions.

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ABSTRAK

Pada bulan Jun 2015, Malaysia terkejut dengan magnitud 6.0 gempa bumi yang melanda Ranau, salah satu daerah di Sabah. Gempa bumi yang sederhana telah memecahkan rekod paling kuat pada tahun 1976, apabila gempa bumi berukuran 5.8 skala Richter melanda Lahad Datu, menyebabkan kerosakan berat terhadap harta dan keretakan ke bangunan. Walaupun Sabah berada di luar Lingkaran Api Pasifik, Pusat Penyelidikan dan Inovasi Universiti Malaysia Sabah mendapati kawasan di Kundasang, Ranau, Pitas, Lahad Datu dan Tawau berisiko terkena gempa bumi. Selepas mengalami gegaran, Malaysia mula menyedari tentang kepentingan reka bentuk seismik mengenai struktur bangunan. Walau bagaimanapun, akibat aplikasi reka bentuk seismik pada kos bahan perlu dipelajari terlebih dahulu. Berhubung dengan itu, kajian ini membincangkan reka bentuk seismik bangunan hotel konkrit bertetulang (RC) dengan pertimbangan magnitud yang berbeza dari pecutan tanah puncak (PGA) dan jenis tanah yang berlainan. Objektif utama kajian ini adalah untuk mengkaji pengaruh PGA terhadap jumlah pengukuhan keluli. Objektif kedua ialah menganalisis kesan jenis tanah pada jumlah pengukuhan keluli. Sepuluh model bangunan hotel dengan pertimbangan jenis PGA dan tanah yang berbeza dipertimbangkan, iaitu bangunan bukan seismik, Tanah Jenis B, Tanah Jenis D, Tanah Jenis E dengan PGA 0.04g, 0.10g, 0.16g. Untuk magnitud yang berbeza PGA, hasil menunjukkan bahawa perbezaan peratusan pengukuhan keluli yang diperlukan berbanding dengan reka bentuk bukan seismik untuk balok dan lajur keseluruhan bangunan telah meningkat daripada 14%, 48% kepada 153% untuk PGA bersamaan dengan 0.04g, 0.10 g, dan 0.16g masing-masing. Sedangkan bagi jenis tanah yang berbeza, hasil menunjukkan bahawa perbezaan peratusan pengukuhan keluli yang diperlukan berbanding dengan reka bentuk bukan seismik telah meningkat dari 79% hingga 153% dan dikurangkan kepada 93% untuk Tanah Jenis B, Tanah Jenis D dan Tanah Jenis E masing-masing. Akibatnya, magnitud PGA dan jenis struktur tanah memberi kesan besar kepada jumlah keseluruhan pengukuhan keluli yang diperlukan. Oleh itu, adalah penting untuk mempertimbangkan parameter ini dalam merekabentuk bangunan seismik.

ABSTRACT

In June 2015, Malaysia was shocked by a 6.0 magnitude of earthquake that had struck Ranau, one of the districts in Sabah. The moderate earthquake has broken the strongest record set in 1976, when an earthquake measuring 5.8 on the Richter scale struck Lahad Datu, causing heavy damage to property and cracks to building. Although Sabah is outside the Pacific Ring of Fire, the Centre of Research and Innovation of Universiti Malaysia Sabah, found areas in Kundasang, Ranau, Pitas, Lahad Datu and Tawau at risk of earthquakes. After been experiencing the tremors, Malaysian start to aware on the importance of seismic design on building structure. However, the consequence of seismic design application on cost of materials need to be studied beforehand. In relation to that, this study discusses on the seismic design of reinforced concrete (RC) hotel building with consideration of different magnitude of peak ground acceleration (PGA) and different soil type. The first objective of this study is to study the influence of PGA on the amount of steel reinforcement. The second objective is to analyse the effect of soil type on the amount of steel reinforcement. Ten models of hotel building with consideration of different PGA and soil type are considered, namely, non-seismic building, Soil Type B, Soil Type D, Soil Type E with PGA of 0.04g, 0.10g, 0.16g. For different magnitude of PGA, the results shows that the percentage difference of steel reinforcement required compared to non-seismic design for beam and column of the whole building had increased from 14%, 48% to 153% for PGA equals to 0.04g, 0.10g, and 0.16g respectively. While for different soil type, the results shows that the percentage difference of steel reinforcement required compared to non-seismic design had increased from 79% to 153% and reduced to 93% for Soil Type B, Soil Type D and Soil Type E respectively. Consequently, magnitude of PGA and soil type of structure give major effect to overall amount of steel reinforcement required. Thus, it is important to consider these parameter in designing a seismic building.

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LIST OF SYMBOLS

α_g	Design ground acceleration
α_{gR}	Reference peak ground acceleration
As_{prov}	Total area of steel provided
As_{req}	Total area of steel required
d_{bL}	Diameter of longitudinal bar
d_{bw}	Diameter of shear or confinement bar
F_b	Base shear force
f_{cd}	Design value of concrete compressive strength
f_{ck}	Characteristic cylinder strength of concrete
Fi	Lateral load on storey
f_y	Yield strength of reinforcement
g	Acceleration due to gravity, m/s^2
G_k	Dead load
H	Storey height
M	Bending moment
m_i	Mass of storey *i*
M_{Rb}	Design moment resistance of beam
M_{Rc}	Design moment resistance of column
M_w	Magnitude of earthquake intensity
N	Number of storey
q	Behaviour factor
Q_k	Live load
S	Soil factor
$S_d(T_1)$	Ordinate of the design spectrum at period
T_1	Fundamental period of vibration
T_B	Lower limit of the period of the constant spectral acceleration
T_C	Lower limit of the period of the constant spectral acceleration
T_D	Beginning of the constant displacement response range of the spectrum
V	Beginning of the constant displacement response range of the spectrum
λ	Correction factor
γ_1	Importance factor

LIST OF ABBREVIATIONS

DCH	Ductility class high
DCL	Ductility class low
DCM	Ductility class medium
JKR	Jabatan Kerja Raya
MMD	Malaysian Meteorological Department
PGA	Peak ground acceleration
RC	Reinforced concrete

CHAPTER 1

INTRODUCTION

1.1 Background

Earthquake is one of the natural disaster which resulting from natural processes of the earth. It also can be called “seismic tremor” which describes as natural phenomenon that suddenly strikes an area causing some damage that varies according to the intensity of the quake and local geological condition. Earthquake can caused the ground shakes and create sudden ground movement that could make any building become unstable.

According to McClure et al. (2011), when an earthquake occurs on a fault, it will releases portion of energy that has been stored in the earth’s crust. Hence, this will makes it less likely that additional earthquakes will occur on this same fault until additional stress can accumulate. Small magnitude earthquakes can liberate small amount of energy and stress, vice versa with large-magnitude earthquakes. However, small magnitude earthquake energy released can be accumulate in just a few of years to decades. While, it may took several hundred years and perhaps several thousand years for energy released by large magnitude earthquake to accumulate.

In year 2015, a 6.0 moment magnitude (M_W) earthquake had struck on the foot of Mount Kinabalu near the highland town of Kundasang in the district of Ranau, Sabah. Since the 1976 earthquake at Lahad Datu happened, this earthquake give the highest impact to Malaysia which the tremor were last to 30 seconds. In addition, the tremors were also felt all over Sabah as far afield as Labuan, Miri and Brunei. This incident jolted the Malaysia’s Mount Kinabalu caused fatality of public 11 hikers and another 8 hikers was missing. It also damaged the Donkey’s Ear, the pride symbol of Mount Kinabalu. This earthquake also felt by West Coast Sabah people included of Tambunan, Tuaran, Kota Kinabalu, and Kota Belud. Weak aftershocks occurred about 47 times around M_W 2.2 to M_W 3.3.The quake alerting the Malaysian engineers about the earthquake awareness on building his incident had cause physical damaged at building and also cause injuries and death to people. (Tongkul, 2016)

Figure 1.1 Location of magnitude 6.0 Ranau earthquake in Sabah (Tongkul, 2016)

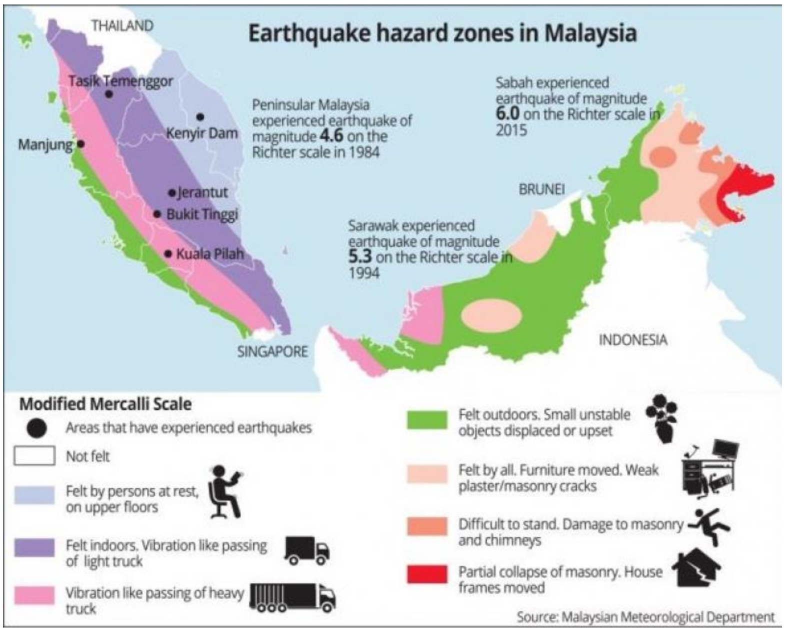

Figure 1.2 Earthquake hazard zones in Malaysia (*Malaysian Meteorological Department*, MMD)

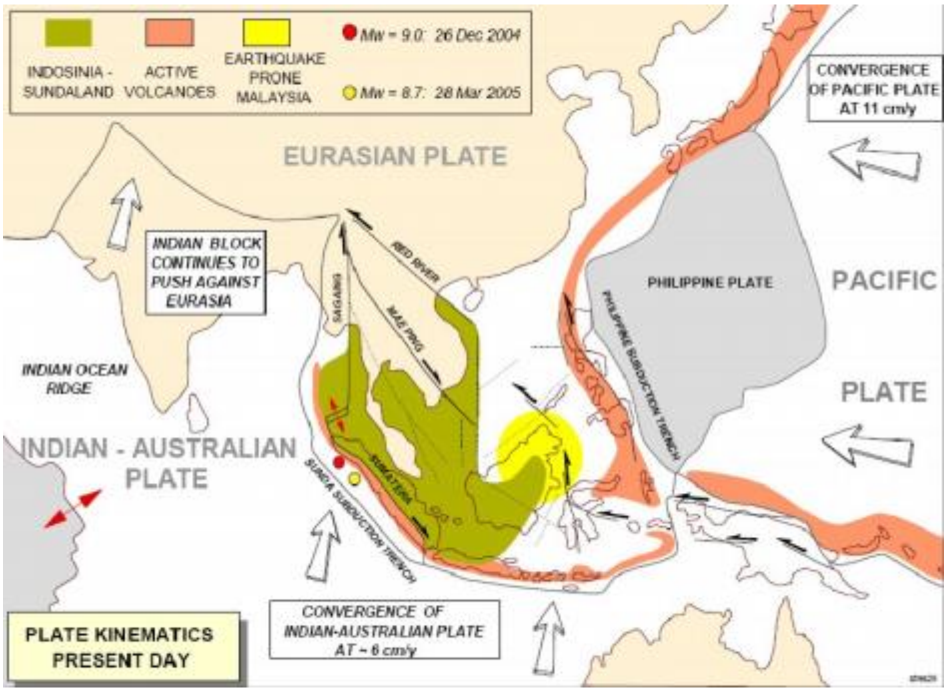

Figure 1.3 Earthquake-prone region in Malaysia (Tija, 2010)

Most buildings in Malaysia had been designed according to BS8110 since Malaysia is not located in active seismic fault zones. However, after been experiencing the tremors, Malaysian start to aware on the importance of seismic design on building structure. (Adiyanto & Majid, 2014). According to Ahmad Jani (2018), damage potential must not be neglected since strong impact of earthquake from neighbouring countries could create considerably ground motion over Peninsular Malaysia even though Malaysia has low seismic risk.

According to Adiyanto (2014), there are several factors that could affect the seismic design structure. For example, location of site, type of soil, Peak Ground Acceleration (PGA), materials and structure type, class ductility, stiffness and behaviour factor, *q*. This study covered on the influence of different magnitude of PGA and the soil type to seismic deign of reinforced concrete (RC) hotel building. These two parameters are significant in specifying earthquake actions for seismic design. The amount of steel required also could be determined through this study. To sum up, in reducing the damages in a structure, this study will determine the effect of different PGA and soil type to seismic design structure.

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